

History of forest insect investigations in British Columbia

This three-part paper describes the history of forest entomology in British Columbia during the past century. The first part discusses programmes and personnel in the federal and provincial governments, private enterprise, and academic institutions. This section was co-authored by current or former employees of these agencies as a reflection of the close co-operation between them over the years ranging from insect management programs, research, and training of forest health personnel. The second part describes a unique federal entomology program, the history of the former Forest Insect and Disease Survey (FIDS) unit of the Canadian Forest Service. The third part is a brief history of the establishment and programmes of the federal Vernon Laboratory, the first permanent facility in British Columbia dedicated to forest insect investigations.

I. Forest entomology education, research, and insect management

- a. Forest entomology in the British Columbia Ministry of Forests and private sector
- b. Teaching and research at academic institutions
- c. Research in the federal government

II. Forest Insect and Disease Survey in the Pacific region

III. The Vernon Laboratory and federal entomology in British Columbia

Throughout the history of forest entomology in BC, there has been substantial and productive interaction between provincial, federal and academic institutions. In addition, industry has supported major initiatives in research, e.g., on ambrosia beetles and bark beetles. Thus, there is unavoidable overlap when attempting to synthesize the contributions of each.

I. Forest entomology education, research, and insect management

P. M. HALL

BC MINISTRY OF FORESTS,
1450 GOVERNMENT ST., VICTORIA, BC, CANADA V8W 9C2

J. M. KINGHORN

1253 PALMER RD., VICTORIA, BC, CANADA V8P 2H8

B. S. LINDGREN

FACULTY OF NATURAL RESOURCES AND ENVIRONMENTAL STUDIES,
UNIVERSITY OF NORTHERN BRITISH COLUMBIA,
3333 UNIVERSITY WAY, PRINCE GEORGE, BC, CANADA V2N 4Z9

J. A. MCLEAN

FOREST SCIENCES, UNIVERSITY OF BRITISH COLUMBIA,
2357 MAIN MALL, VANCOUVER BC, CANADA V6T 1Z4

L. SAFRANYIK

NATURAL RESOURCES CANADA, CANADIAN FOREST SERVICE,
PACIFIC FORESTRY CENTRE, 506 WEST BURNSIDE ROAD,
VICTORIA, BC, CANADA V8Z 1M5

a. Forest entomology in the British Columbia Ministry of Forests and private sector

Background

"For several years reports have been received from various points in British Columbia indicating considerable loss from Bark-beetle attack to standing timber and logs. The lumber industry of the province is of such importance, and the destruction by forest insects in the States to the south has been reported as so serious in recent years, that it was thought advisable to make a survey of the actual conditions in regard to injurious forest insects in British Columbia forests. The Forestry Branch of the Department of Lands of British Columbia had in the meantime requested the Division of Entomology to undertake such an investigation. Accordingly, with the assistance and co-operation of the Provincial Forestry Branch, a survey was made during the summer of 1913 the object of which survey was to determine the location and extent of the chief forest insect injuries, and to decide upon proper control measures for the more serious outbreaks." (Swaine 1914)

And so began the history of forest entomology in British Columbia. Until relatively recent times, the British Columbia Forest Service (BCFS) did not employ entomologists or pest management personnel; it relied on the federal government and universities for this expertise. However, there were numerous instances where the BCFS continuing interest in forest insect impacts and management was shown.

The Chief Forester of British Columbia, Mr. H.R. MacMillan, made the initial request to the Division of Entomology and provided funding support to J.M. Swaine to carry out the survey. Subsequently, the BCFS utilized the expertise of federal entomologists such as R. Hopping in supervising a number of bark beetle control efforts utilizing crews for falling and burning infested trees and directed harvesting of infested stands and trees. These control programs were funded by the provincial Forest Service (Hopping 1921). As bark beetle infestations continued to arise, so did further control programs, still relying on federal entomologists for professional expertise (Hopping and Mathers 1945).

The vast and diverse forests in British Columbia result in a similar diversity of forest insects, many of which can cause damage that affects different forest resource values. However, timber losses have long been of greatest interest to management agencies and industry. Through the years, each decade presented the province with one or more major insect-related issues, most often in the form of extensive outbreaks of bark beetles, *Dendroctonus* spp., or defoliators.

Up until about the 1960s, much of British Columbia's forest industry was concentrated in coastal areas. However, the extensive stands of spruce, *Picea* spp., and lodgepole pine, *Pinus contorta*, in the interior of the province beckoned, and, as markets increased forest industry operations in the interior areas of the province expanded.

The modern era

A major step towards a provincially coordinated forest pest management program came in 1974 when the Forest Pest Review Committee (FPRC) was formed (Pearse 1976). This committee was chaired by the Chief Forester for British Columbia and was comprised of representatives from the Forest Service, other provincial and federal agencies, and industry associations. The purpose was to discuss specific insect and/or disease outbreaks and make recommendations as to management directions. Several issues in the 1970s made the committee relevant and very active:

- the beginnings of the Chilcotin outbreak of mountain pine beetle;
- mountain pine beetle outbreaks in the Prince Rupert Region and in the Flathead Valley in Nelson Region;

- the beginnings of the Bowron Lakes spruce beetle outbreak;
- a large scale trial of treatments against Douglas-fir tussock moth in the Kamloops Region carried out in co-operation with the US Forest Service;
- proposed spraying of a western spruce budworm outbreak in the Fraser Canyon; and,
- the first detection of gypsy moth in British Columbia found in Kitsilano.

In response to the major forest insect and pesticide related issues, Mr. **J.M. (Mike) Finnis** was hired by the Protection Section of the BC Forest Service to act as an in-house advisor and specialist in pest management issues. Mr. Finnis served primarily as a co-ordinator of activities and as liaison between provincial and federal agencies (most notably the Canadian Forestry Service). **Paul Wood** was hired by the Cariboo Forest Region in the mid-1970s to address the increasing mountain pine beetle outbreak. Additionally, the Forest Service routinely provided summer students to assist Canadian Forestry Service entomology researchers.

The report from the Royal Commission on Forest Resources was published in 1976 (Pearse 1976). This report made a series of recommendations to change how the forest resource was managed and administered in British Columbia. It set the stage for the creation of the Ministry of Forests Act (Anon. 1978a) and the Forest Act (Anon. 1978b). These legislative acts gave a mandate to the Ministry of Forests to “manage, protect and conserve the forest and range resources of the government, having regard to the immediate and long term economic and social benefits they may confer on British Columbia” (Section 4b, BC Ministry of Forests Act, 1978). The new legislation led to a large-scale reorganization of the British Columbia Forest Service in 1980.

Staffing up

By 1979 it became clear that the Forest Service required some in-house expertise, who were capable of training field staff, advising the Ministry Executive on forest health issues, and implementing large and small management programs. In early 1980, Mr. **R.S. (Bob) Hodgkinson** was hired as a forest entomologist by the Forest Service Protection Branch and based in, Prince George, to evaluate the use of trap trees for reducing losses caused by spruce beetle, and Mr. **P.M. (Peter) Hall** was hired as the regional forest entomologist for the Cariboo Forest Region, Williams Lake, BC.

The reorganization of the Forest Service progressed through the summer of 1980. For the first time, the provincial government staffed professionals in pest management positions. In Victoria headquarters, the positions of a Manager, Pest Management (**R.F. (Bob) Deboo**), Forest Entomologist (P.M. Hall), Forester (Mike Finnis) were filled. Later, a Forest Pathologist (**J.A. (John) Muir**) and a Pesticide Specialist (**J.F. (John) Henigman**) were added to the Pest Management Section at Protection Branch. Branch personnel are responsible for developing policy and procedures, advising the Ministry Executive and Government, providing co-ordination with other provincial, federal and private agencies, monitoring management programs at the regional and district level, and providing expert technical advice. The name of the Pest Management Section was changed to Forest Health in 1990 to reflect a shift in philosophy away from traditional pest control and towards more integrated forest management.

At the regional level, Pest Management Co-ordinators were staffed at each of the six regional offices:

Region	Location	Initial Pest Management Co-ordinator	Subsequent Health Positions	Forest Forester
Cariboo	Williams Lake	D. Doidge	M. Hamm*	
Kamloops	Kamloops	R. Edwards	D. Calder*	
Nelson	Nelson	A. Renwick	J. Monts E. Morris R. Stewart*	
Prince George	Prince George	R. Cozens	S. Taylor*	
Prince Rupert	Smithers	V. Barge	M. Geisler B. Young*	
Vancouver	Vancouver	S. Raine	P. Wood R. Heath*	

* the last to hold the position

The position of Pest Management Co-ordinator was eliminated in 1987 and was replaced in various regions with the position of Forest Health Forester. The latter position was not necessarily supervisory to the regional forest entomologist.

The regional entomologist position evolved from necessity in those regions experiencing a wide variety of issues. Staffing of this position occurred over a period of years, with the formal creation of the position in 1984:

Region	Location	Forest Entomologist	
		Initial*	Subsequent*
Cariboo	Williams Lake	P. Hall	R. Heath L. Rankin*
Kamloops	Kamloops	R. Chorney	T. Maher L. Maclauchlan*
Nelson	Nelson	D. Gray	E. Morris A. Stock*
Prince George	Prince George	R. Hodgkinson*	
Prince Rupert	Smithers	A. Stock	T. Ebata K. White*
Vancouver	Vancouver/ Nanaimo	E. Jeklin	D. Heppner*

*the last (current) to hold the position

Regional entomologists are responsible for providing expert technical advice to regional and district staff, co-ordinating and monitoring management programs, training, and liaison with other agencies, industry and the public. Regional forest pathologists were also hired in most regions.

Additionally, entomologists or pest management specialists were hired in other areas of Ministry of Forests operations:

Position	Specialist/Entomologist*
Nursery Pest Management Specialist	G. Shrimpton D. Trotter*
Cone and Seed Pest Management Specialist	D. Summers R. Bennett* (Victoria) W. Strong* (Vernon)

*the last (current) to hold the position

No specific pest management staff were placed in district offices at that time; the District Resource Officer – Protection, carried out the function of pest management. Since then, several districts with ongoing forest health issues have established a Forest Health officer position. Many of these staff have provided long-term continuity to insect management programs at the district (operational) level. District staff has contributed substantially to the development of management programs, and has been instrumental in ensuring that the BC Forest Service remains one of the best Forest Health organizations in North America.

Contractors and industry

The forest industry has usually depended upon the Canadian Forestry Service, the universities, and the BC Forest Service for professional entomological advice. They also regularly employ consultants and contractors to carry out specific studies or projects relating to forest entomology. There have, however, been instances where the industry directly employed entomologists, particularly to deal with issues such as ambrosia beetles which were beyond the mandate of the BC Forest Service. After his retirement from the Canadian Forest Service, H.A. Richmond consulted to MacMillan-Bloedel to deal with ambrosia beetle damage, and he was later employed as an in-house consultant to the Council of Forest Industries. He provided advice on a variety of forest insect issues (Richmond 1983). Further, Pacific Forest Products hired **R. (Dick) Heath** as a pest management specialist, Northwood Pulp and Timber hired **T. (Tom) Maher**, and Finlay Forest Industries of Mackenzie, BC, hired **D. (Darrell) Devlin** to deal with pest management issues. At the current time, though, no BC forest company has an entomologist on staff.

Examples of companies that have provided a wide variety of products and services in forest entomology, are Phero Tech Inc., Delta, BC, and Bugbusters Pest Management, Prince George, BC. Phero Tech is one of the major North American companies providing commercial quantities of forest insect pheromones. Both of these companies, as well as other consulting companies, have employed numerous forest entomologists over the past 15 years.

The number of consulting entomologists and pest management specialists has increased dramatically in British Columbia since 1980. The increasing interest in and management of forest insects has created varied opportunities for individuals and companies with entomological expertise. Downsizing of federal and provincial agencies, as well as

increased interest in the field by students entering graduate programs at universities, have contributed to a growing pool of talented individuals who have contributed to the development and refinement of management of forest insects in the province. A listing of individual contractors and companies is impractical in this publication and it would be impossible to ensure that all deserving individuals were included.

Milestones and accomplishments

The Ministry of Forests has accomplished a great deal in the area of forest entomology and management of the forest resource to reduce damage caused by insects. The Forest Service has evolved from an organisation primarily reacting to crisis to having ongoing integrated programs and staffing dedicated to dealing with all aspects of forest insect biology and management. Some of the accomplishments have been specific to a particular insect problem, while others have been in the realm of legislation and program integration and acceptance. All of the accomplishments have been achieved through the close working relationship between the forest entomology "team" of the Forest Service.

Some of what has been done is briefly noted in the following table:

Issue	Insect	Accomplishment
Legislation	All	Incorporation of forest health principles into all aspects of the Forest Practices Code of BC Act and Regulations (Anon., 2001).
Staffing	N/a	Forest Entomologists are in place in all 6 Forest Regions, Victoria headquarters, Cone and Seed Program, and Nursery Program. Several Forest Districts have dedicated Forest Health Officers.
Manuals and Publications	N/a	Management guidebooks for a wide variety of forest insects have been produced under the authority of the Forest Practices Code of BC Act. These include guidebooks for bark beetles, defoliators, terminal weevils and others. Extension literature and publications are now available. The Ministry of Forests website contains a great deal of information relating to forest entomology: http://www.gov.bc.ca/for/
Surveys	All	The Forest Service is now responsible for conducting the annual aerial overview survey formally conducted by the FIDS Unit of the CFS. The responsibility for this survey was assumed by the province in 1996 and has been fully implemented in 2001.
Support	All	The Forest Service has consistently supported research efforts by the Canadian Forestry Service and universities through direct funding or provision of logistical support.
Specific Management	Bark Beetles	The Forest Service was responsible for operationally implementing the use of aggregation pheromones for bark beetle management.

Large-scale operational management programs for mountain pine beetle, Douglas-fir beetle and spruce beetle have been conducted periodically. Expenditures on these issues have exceeded \$10 million annually.

Province-level and landscape-level strategic planning frameworks have been developed and accepted by all levels of the Forest Service and industry.

Ongoing support and encouragement for the development of predictive modelling techniques to improve understanding of population dynamics and the impacts of management efforts (e.g., SELES/MPBSIM)

The items noted in the table below show a small subset of the accomplishments in forest entomology achieved by the forest entomology professionals within the Ministry of Forests. This group has consistently worked co-operatively together and with others to ensure that management objectives are met and that impacts of forest insects are minimized.

Insect	Accomplishment
Douglas-fir tussock moth	The Forest Service was the first jurisdiction to use nuclear polyhedrosis virus operationally to terminate DFTM outbreaks. And the Forest Service has implemented an integrated detection, evaluation and treatment system for this insect. A true Integrated Pest Management System.
Spruce weevil	The Forest Service has actively supported the development of assessment models and identification and propagation of resistant genotypes of spruce.
Gypsy moth	The Forest Service has actively supported and participated in efforts to maintain British Columbia free of gypsy moth. Completed a detailed Risk Assessment for gypsy moth in British Columbia

Major issues

Currently, forest insect issues in British Columbia relate to the same insects as in the past: bark beetles, defoliators, ambrosia beetles, terminal weevils and regeneration problems, and others. However, new issues arise that deal with responsibility-sharing between government and industry, changing management objectives over time, new legislative initiatives, introduction of exotic, potentially damaging insects, encouraging and implementing new survey and management technologies, and, as always, trying to grapple with a class of organisms that often seem to be better at what they do than we are at doing what we do. Perhaps they just have more experience.

b. Teaching and research at academic institutions

Research on forest insects has been conducted at all major institutions in British Columbia. Some of the major contributions are listed in the next Table.

The earliest collections of insect damaged wood in the collections at the University of British Columbia bear the name of Dr. **G. (George) Spencer**. Materials he collected more than half a century ago are still in use at the Faculty of Forestry today. Forest Entomology has always been a core subject in the academic programs for students wishing to become professional foresters. The first full time professor of forest entomology was Dr. **K. (Ken) Graham** whose interests were in ambrosia beetles and bark beetles. He also wrote one of the first texts in Forest Entomology (Graham 1963). His successor in 1977 was Dr. **J.A. (John) McLean** who also was interested in the general biology of ambrosia beetles, especially the population surveys and mass trapping in sawmills with pheromone-baited traps as well as economic impacts of attacks on lumber values. His graduate students have contributed to our knowledge on ambrosia beetles, defoliators and leader weevils. Several of McLean's graduate students hold prominent positions with the BC Forest Service and the Canadian Forest Service, Victoria, BC. Several other UBC professors have also contributed to forest entomology studies, especially in the areas of population modelling, Dr. **C.S. (Buzz) Holling**; in tent caterpillar and biological control studies, Dr. **J. (Judy) Myers**; as well as in insects and weather, Dr. **W.G. (Bill) Wellington**. In recent years concerns for sustainable forest management have centered on biodiversity studies of carabids, sucking insects and bark beetles by Dr. **G. (Geoff) Scudder** and riparian insects by Dr. **J. (John) Richardson**. Dr. **M.B. (Murray) Isman** studied the effects of botanical insecticides, e.g., neem, on many insects, including forest seedling nursery pests and the mountain pine beetle.

A strong chemical ecology research group was established by Dr. **J.H. (John) Borden**, along with chemists **K.N. (Keith) Slessor** and **A.C. (Cam) Oehlschlager**, at Simon Fraser University (SFU) in the 1970s. Many of Dr. Borden's graduate students, who over the last 35 years have completed the Master of Pest Management program, as well as more traditional Masters and Ph.D. programs, now contribute professionally to forest entomology in BC and are mentioned elsewhere. The SFU team, led by Dr. Borden, and graduate students have made milestone contributions to the chemical ecology of forest insects. Over the years, they have identified numerous forest insect pheromones, many of which have been put to use in pest management applications.

Issue	Significant contributions
Bark beetle ecology and management	Significant contributions in the field of chemical ecology and basic biology of numerous important bark beetle species. Development of applications. Ongoing investigations in the role of anti-aggregation pheromones and non-host odours.
Ambrosia beetle ecology and management	Identification and synthesis of semiochemicals for the most important species, and development of applications, many of which are commercially available. Important findings regarding economic impact to coastal industry.
White pine weevil ecology and management	Important discoveries on host selection and host resistance mechanisms in collaboration with CFS.
Seed and cone insect ecology and management	Development of semiochemicals and investigations on the ecology and impact of significant seed and cone insects in collaboration with BCFS and CFS.

Dr. **G. (Gerhard) Gries** is currently very active in the area of identification of semiochemicals in forest insects. Drs. Borden and Gries teach graduate courses in forest pest management and forest entomology at SFU. In the early program at Simon Fraser, Dr. **B. (Bernie) Roitberg** supervised several graduate students studying mate selection behavior in bark beetles. Dr. **A. (Bert) Turnbull** wrote on biological control (Turnbull and Chant 1961), **T. (Thelma) Finlayson** described many hymenopterous parasites, and Dr. **J. (John) Webster** studied interactions between nematodes and insects, especially the pinewood nematode.

Forest entomology is taught as part of a Forest Health course at the University of Northern British Columbia by Dr. **B.S. (Staffan) Lindgren**, whose major interests are in forest insect ecology and management. At the University of Victoria, extensive studies on the biodiversity of insects in the tree crowns of mature coastal rain forest have been conducted by Drs. **R. (Richard) Ring** and **N. (Neville) Winchester**.

Technicians trained at the Technical Institutes and colleges in British Columbia have received their forest entomology education from a number of instructors over the years, and it would be impractical to name all of them here. Suffice it to say that forest entomology is taught at every major college and University College in BC. As well, teachers and researchers at these institutions have made important contributions to forest insect biology and management.

c. Research in the federal government

The following is a brief overview of entomology research conducted by the federal Government in British Columbia. We have listed the scientists grouped approximately by the decade in which they commenced permanent employment. For each scientist, we give a brief description of the main subject area(s) of work and/or the highlight of accomplishments. We do not give a complete list of laboratory and research directors as this list is available elsewhere. Instead, we listed only those managers who were trained entomologists and did some forest entomology research during their careers. We made an effort to provide a complete list of all scientists who, at least some time during their careers, were permanently employed by the federal government and worked at one or more of the three entomology labs (Vernon, Vancouver, Victoria). We sincerely apologize for inadvertent omission of any names. In compiling this information we drew upon our personal knowledge and the following references: Richmond (1983); Riegert (1991); and Swaine (1918).

The early years

Significantly, organized forest insect investigations in British Columbia by the dominion government were started in response to extensive outbreaks by bark beetles during the first three decades of this century. The following quote from C. Gordon Hewitt, Dominion Entomologist in Ottawa described the bark beetle problems that existed up to 1917 as follows.

“The bark-beetles constitute the chief insect enemies of our coniferous forests, and it is impossible to give even an approximate estimate of the enormous annual loss caused by their depredations throughout Canada. Much of the dead timber whose destruction is attributed to fire is the result of outbreaks by bark beetles; this is particularly true in British Columbia.”

To this day, bark beetles affecting mature pines, spruces, Douglas-fir and sub-alpine fir collectively remain the most important cause of tree mortality from forest insects in the Province.

Although not residing in British Columbia, *J.M. Swaine* was the first dominion government entomologist to carry out major investigations of forest insect biology and management in the Province. During these early years, there was a lack of information on the taxonomy, bionomics, and methods of coping with, destructive bark beetles. In response to the urgent need for this basic information, and the constant demand by lumbermen, foresters and others for practical methods of control, J.M. Swaine, Assistant Entomologist in charge of Forest Insect Investigations, undertook a study of the Canadian bark beetle fauna. This work culminated in the publication in 1917-18 by the Dominion of Canada, Department of Agriculture of the two-part Bulletin No. 14 entitled Canadian bark-beetles. It describes several new species from British Columbia. In 1918 The Commission of Conservation, Canada Committee on Forests published *Forests of British Columbia* which included a chapter by Swaine on injurious forest insects. He described outbreaks of bark beetles affecting ponderosa, western white and lodgepole pine, Engelmann and sitka spruce, western hemlock, lowland and alpine fir. Most of these outbreaks were occurring in the southern interior and the southern Rockies.

The beginning of organized research

R. (Ralph) Hopping was hired from California by the Federal Government in the late 1910s to organize suppression programs against outbreaks of the mountain pine and the western pine beetle in ponderosa and lodgepole pines in the Nicola-Aspen Grove-Merritt areas. The Provincial Government financed the control operations. In 1923 J.M. Swaine established the first dominion government forest insect laboratory in Vernon and R. Hopping was appointed to undertake a program of forest insect investigations in British Columbia and Alberta. Initially, the total staff of the Vernon laboratory consisted of four persons: R. Hopping in charge; his son *G. (George) R. Hopping*, assistant: *H. (Hec) A. Richmond* and *W. (Bill) G. Mathers*, research assistants. For the next two decades, these entomologists made significant contributions to our knowledge of bark and ambrosia beetle biology and control, and the biology and control of some important wood borers (e.g., the red cedar borer) and defoliators (e.g., the hemlock looper, blackheaded budworm). *H. (Hugh) B. Leech* collaborated with W.G. Mathers on aspects of bark beetle research. In his Masters thesis, H.A. Richmond produced the first morphologic description of adult mountain pine beetles. G.R. Hopping became an authority on the North American bark beetle genus *Ips*.

Expansion of entomology investigations

The early 1940s saw a great proliferation of defoliator outbreaks in the coastal regions of the Province. Dr. *M. (Malcolm) L. Prebble* was transferred from Fredericton to British Columbia and established a forest insect laboratory in Victoria. He was joined by Dr. *K. (Ken) Graham* and together they carried out detailed investigations of the nature and causes of outbreaks in the coast hemlock forests by a number of defoliating insects such as the blackheaded budworm, the hemlock looper, the hemlock sawfly, and the rusty tussock moth. These investigations included the nature of natural control and considerations for chemical treatment. *D. (Don) N. Smith* and *G.R. Wyatt* assisted with various phases of this work as well as with subsequent studies by M.L. Prebble and K. Graham on the biology and damage caused by ambrosia beetles in softwood lumber on Vancouver Island. D.N. Smith's main research areas involved nursery and regeneration insects and insect pests of wood in service. In 1948 K. Graham became professor of forest entomology at UBC and M.L. Prebble transferred to Sault Ste. Marie, Ontario. Dr. *M. (Margaret) R. MacKay* worked as a taxonomist at Vernon until 1949 when she was transferred to Ottawa.

E.D. (Dave) A. Dyer and *J. (Jim) M. Kighorn* both joined the entomology laboratory in Victoria in 1946 as student assistants and later (1950) as permanent staff. Over a long,

productive career that spanned three decades, J.M. Kinghorn made major contributions to our knowledge of hemlock looper biology, especially the effect of stand conditions on its epidemiology; ambrosia beetle management, and chemical control of the mountain pine beetle. During the last decade prior to retirement, he switched careers and pioneered development of containerized production of seedlings for reforestation. E.D.A. Dyer and Dr. **J. (John) A. Chapman**, who joined the entomology lab in Victoria in 1952, were among the first scientists to demonstrate pheromone production in ambrosia beetle and spruce beetles. E.D.A. Dyer also made significant contributions to the biology and management of the spruce beetle. Other scientists that joined the entomology lab in Victoria during the late 1940s were **S. (Stu) Brown**, **M.G. Thomson**, and **J. (Jack) Walters**. S. Brown worked on population change in the mountain pine beetle and, in collaboration with J.A. Chapman and J.M. Kinghorn, ambrosia beetle biology and management. M.G. Thomson and J. Walters conducted one of the first investigations in the Province on spruce beetle biology; the former also worked on hemlock looper and ambrosia beetle problems.

Dr. **W. (Bill) G. Wellington** joined the Victoria lab in 1953. He made fundamental contributions to the field of bio-meteorology and insect ecology, especially studies of insects and climate, and individual differences among insects as factors in population dynamics. **R (Ray) R. Lejune** replaced H.A. Richmond as officer in charge of the Victoria lab in 1955 as the latter started a highly successful career as an entomology consultant; he was the first entomology consultant in the Province. **A. (Al) F. Hedlin** moved to Victoria from the Indian Head station in 1954. He worked on seed and cone insects, became an international authority on the subject and authored and co-authored a number of definitive publications on seed and cone insects and their management in Canada and North America. Dr. **L. (Les) H. McMullen** joined the forest insect lab in Vernon in the early 1950s and moved to the Victoria lab in 1954. In collaboration with Dr. **M. (Mike) D. Atkins**, who joined the Victoria lab in the mid 1950s, Dr. McMullen carried out the first comprehensive investigations of the ecology of the Douglas-fir beetle in British Columbia. These studies included flight capacity and dispersal, brood mortality in relation to natural factors, and the effects of stand conditions and harvesting practices on beetle populations. This work has led to the development of the highly effective "Douglas-fir beetle clauses" in the early 1960s which were written into timber sale licenses in high beetle hazard areas in the BC interior to ensure sanitary logging practices and treatment of logging residue. Dr. McMullen has also contributed to studies of mountain pine beetle dispersal and the sitka spruce weevil biology and management, being the major author of the first computerized model of spread, intensification of damage and direct control. **M. Seger** and **S. (Sergei) F. Condrashoff** joined the Victoria lab during the early 1950s. Mr. Seger, an insect pathologist, investigated disease associations of damaging forest lepidoptera. Condrashoff worked on the biology of needle and leaf-mining insects and regeneration pests such as the weevil *Steremnius carinatus*. Dr. **D. (Doug) A. Ross** joined the Forest Insect and Disease Survey (FIDS) unit at Vernon in 1950. The main areas of his research were wood borer biology and control. **D. (Dave) Evans** joined the FIDS as a taxonomist in the early 1950s. The main areas of his research concerned the life histories of forest insect pests and introductions of exotic natural enemies for controlling forest defoliators. Dr. **G.T. (Tom) Silver** replaced E.D.A. Dyer as FIDS Survey Head in 1953. Dr. Silver made important contributions to several fields including the biology of several species of forest defoliators, sitka spruce weevil biology, and sample survey methods. Dr. **D. (Don) K. Edwards**, insect physiologist, joined the insect lab in Victoria in the late 1950s. A productive scientist, Dr. Edward's work was centered on techniques for measuring activity rates and rhythms in insects such as the effects of electrical fields or acclimatization, and development of sampling techniques to measure defoliator density.

The new forest research laboratory was opened on Burnside Road, Victoria, during the early 1960s and all subsequent entomology work was done out of this facility with the exception of a few entomologists working with the FIDS who remained in the Vernon until 1970 when that laboratory was closed. Dr. *C.S. (Buzz) Holling* worked at the Victoria lab during the 1960s. His main interest and work concerned basic principles of insect predation and process modelling in insect ecology. He was recognized internationally as an authority on these subjects. In 1960, Dr. *O. (Ozzie) N. Morris* succeeded M. Sager as insect pathologist. He investigated, and produced a catalogue of insect pathogens associated with forest lepidoptera in British Columbia. Drs. *J.R. (Rod) Carrow* (entomologist), *D.B. (Bir) Mullick* and *G. (George) S. Puritch* (plant physiologists) joined the entomology research group in the mid-1960s. Their research focussed on the nature and effects of resistance in true firs to the balsam woolly aphid, and induced physiological and biochemical changes in the tree as it affected aphid establishment and survival. Dr. *J. (John) W.E. Harris* who joined the FIDS unit in 1964, collaborated with assessment of natural enemy complexes associated with the balsam woolly aphid. Other accomplishments included the biology of the poplar and willow borer, development of survey methodology, including remote sensing, and assessment of the effectiveness of introduced parasites and predators in controlling the larch sawfly, the larch casebearer and other forest insects. Dr. *T. (Tara) S. Sahota*, insect physiologist, joined the entomology research group in 1967. He made important contributions to several fields including hormonal regulation of metamorphosis and reproduction in bark beetles, and quality of individual insects as affecting numerical changes in populations. Currently semi-retired, his work during the past 5 years concerns the reproductive physiology and behaviour of the spruce weevil as affected by host factors. *D.R. (Ross) Macdonald* moved to PFC from the Fredericton lab in 1968 to become Section Head, Forest Entomology. In 1969 he became Program Director for Forest Protection. After serving as Director of the Forest Protection Branch in Ottawa, Mr. Macdonald became Director General, Pacific and Yukon Region (1980-87), Canadian Forest Service (CFS), a post from which he retired. Mr. Macdonald's research experience and expertise included spruce budworm ecology and the effects of spray operations on budworm natural enemies. Dr. *R. (Roy) F. Shepherd* moved to Victoria from the Edmonton lab of CFS in 1969 to undertake researches on the population biology and management of defoliating insects. This research has led to development of sampling methods for several defoliators, development of pest management methods for the Douglas-fir tussock moth and the black army cutworm, monitoring systems for endemic populations with pheromone traps, and prevention of outbreaks through early treatment with nuclear polyhedrosis virus.

Dr. *H. (Henry) A. Moeck* joined the bark beetle research group in Victoria from the Forest Products Laboratory in Vancouver in 1970. His field of research involved primary attraction in bark and ambrosia beetles and assessment of native and exotic natural enemies of bark beetles as potential biocontrol agents. Dr. *S. (Steve) Ilnytsky* joined the entomology group at PFC in the early 1970s. His main research concerned the use of pesticides in insect control. He developed bioassays of insecticide residues in soils and investigated phytotoxicity of pesticides to forest seeds. *C. (Cliff) E. Brown* moved to PFC from Ottawa in 1972 to become a Program Manager and Deputy Director, positions from which he retired. The focus of Mr. Brown's earlier work concerned the development of automated recording of FIDS data at regional and national levels. Drs. *M. (Malcolm) D. Shrimpton* (tree physiologist), *H.S. (Stu) Whitney* (plant pathologist) and *L. (Les) Safiranyik* (insect ecologist) were transferred to Victoria from the Edmonton lab of CFS in 1972 in order to concentrate bark beetle research in CFS at the Victoria lab as these insects continued to be the most destructive in the forests of British Columbia. Based largely on previous research in the East Kootenays by this team and colleagues from Alberta, they

produced two milestone publications on the mountain pine beetle in 1974: "An interpretation of the interaction between lodgepole pine and the mountain pine beetle with its associated blue stain fungi in Western Canada" and "Management of lodgepole pine to reduce losses from the mountain pine beetle" The first paper describes the nature and affects of the three-way interactions among the host, beetles and fungi and their role determining the course of infestations. The second paper, intended for practicing foresters and forest health specialists, emphasizes that in order to effectively cope with the beetle the focus of management should be lodgepole pine and not the beetle. This publication was an all time "best seller" in Canada and the United States; two printings of a couple thousand copies each are sold out. Other major publications followed on the population dynamics of the spruce beetle. Dr. Safranyik's current research involves a population dynamics model of the mountain pine beetle, competitive exclusion of the mountain pine beetle, and spruce beetle ecology. Dr. *A. (Al) J. Thomson* joined PFC in the late 1970s. An insect ecologist but not formally part of the entomology research group, Dr. Thomson does much work of entomological nature such as a landscape-level model for mountain pine beetle, collaborative work on bark beetle population quality with Dr. Sahota and a mountain pine beetle model with Dr. Safranyik. *H. (Howard) A. Tripp* succeeded Dr. Silver as FIDS Survey Head in 1973. His interests were biological control and seed and cone insects. Dr. *C.D. (Doug) F. Miller* moved to PFC from Ottawa to become Research Program Manager in 1978. His entomological work was done in agriculture concerning the taxonomy of ants, wasps and parasitic insects. Dr. Miller has published several monographs on the classification of these insects.

Dr. *G. (Gordon) E. Miller* joined PFC to take over seed and cone insect research following the retirement of A.F. Hedlin in 1980. Dr. Miller's research work was centered on the population ecology and management of cone and seed insects and produced over 30 scientific and technical papers on these subjects. Since 1986 he pursued a career in management and is currently Director of Research for CFS in Ottawa. Dr. *I. (Imre) S. Otvos* moved to PFC from the Newfoundland lab of CFS in 1981. His main work at PFC centers on the use of natural enemies (predators, parasitoids, fungi, bacteria and viruses) for controlling defoliating insects. Some major accomplishments include assessment of the potential of introduced parasitoids and fungal pathogens for the control of the hemlock looper; pioneering the concept of creating epizootics of naturally occurring pathogens to control defoliators, and co-developing with Dr. R.F. Shepherd a management system for Douglas-fir tussock moth. Dr. *R. (Rene) I. Alfaro* joined the FIDS program in 1980 and was assigned to entomology research full time a few years later. The main foci of his research are quantification of damage caused by forest pests, management and ecology of the spruce weevil with emphasis on the nature of host resistance and host-insect interaction. His comprehensive research on insect impacts has enabled private and provincial pest management agencies to measure potential losses and to justify control programs. Continuing work on weevil-host interactions resulted in numerous scientific and technical papers concerning the nature and effects of host resistance, and the dynamics of intensification and spread of infestations at the tree, stand and landscape levels. Dr. *M. (Mike) A. Hulme* joined PFC from the Eastern Forest Product Laboratory in 1982. The main area of his work involves biological control. Dr. Hulme co-edited the book entitled "Biological control programs against insects and weeds in Canada 1969-1980". Other accomplishments include demonstration of pheromone-based mating disruption in Douglas-fir tussock moths, a first in this field, and showing that host phenology has a major affect on resistance to the sitka spruce weevil. Dr. *T. (Terry) L. Shore* transferred from the FIDS to bark beetle research in 1985 following the retirement of Dr. L.H. McMullen. His main areas of research are development of hazard-risk rating systems and decision support systems to enable forest managers to develop effective and efficient

programs of managing destructive bark beetles. A system for rating lodgepole pine susceptibility and risk of loss from mountain pine beetle developed by Drs. Shore and Safranyik is included in the bark beetle management guidelines section of the Forest Practices Code for the province, and is being widely used by forest protection staff in industry and government in BC as well as in neighbouring states in the USA. Dr. **H. (Hugh) J. Barclay**, an insect ecologist, joined the growth and yield program at PFC in 1982. Although his research assignments were, and continue to be, in a field other than entomology, he has authored and coauthored a number of scientific papers on entomological subjects. Significant contributions include the mathematical treatments of sterile males, inundative releases of natural enemies, for controlling insects, and contribution to the development of interactive models of spruce beetle and mountain pine beetle population dynamics. Dr. **L. (Lee) M. Humble** joined FIDS in 1985 as an insect taxonomist. In addition to the taxonomic work, his main areas of research include insect biodiversity, specifically the diversity of canopy-dwelling insects in the boreal forest, and the establishment and biology of introduced insects.

Following program reorganization in CFS during the mid-1990s two entomologists transferred to PFC from other CFS establishments: Dr. **V. (Vince) G. Nealis** from Sault Ste. Marie and Dr. **A. (Allan) L.C. Carroll** from St. John's, Newfoundland. Dr. Nealis is developing a program on the population ecology of spruce budworms in British Columbia. The focus of Dr. Carroll's current work involves investigations of the ecology of mountain pine beetle populations in the endemic state.

Technical support

The contributions of technical support staff to all phases of research and development are highly important and impressive. Some technicians, owing to special skills and or experience gained on the job, had their own research projects which they conducted semi-independently from the research officer in charge. For example, W. (Bill) W. Nijholt has made substantial contributions to ambrosia beetle management and pioneered the use of pine oil for controlling bark and ambrosia beetles and, with H.A. Richmond, water-misting of log decks in dry-land sorts to reduce ambrosia beetle damage. Some others who worked in similar manner are T. (Tom) G. Gray on pheromone-based monitoring of defoliators and R. (Bob) Duncan in insect taxonomy. Still others co-authored an impressive list of scientific and technical papers.

Trends in research

Of necessity, much of the research conducted during the first 25 years or so involved identification, taxonomic description, geographic distribution, and exploratory work on the biology and control of injurious forest insects. Due to shortage of manpower and expertise, often a single scientist was assigned to work on several problem areas involving several insect species in different taxa. With an increase in the number of scientists assigned to forest entomology, research became specialised. Scientists normally worked in a single field such as physiology, population ecology and often with one or a few related species such as the budworms. There was an emphasis on studying insect populations under outbreak conditions. Research projects, however, were still mainly headed up by single scientists. This general trend continued to the beginning of the 1970s. From this time on, gradually there was a change from studies of epidemics to studies of factors affecting populations in the endemic state. As well, there was more emphasis on insect management through cultural practices and natural enemies. Multidiscipline team approaches to tackling difficult problems became more prevalent. These trends continue today but with greater emphasis on development of practical decision support systems that are based on a solid ecological foundation. There is increased need for understanding the interactions of insects

with their host trees and the host environment at the landscape level and the consequences of natural and man-made disturbances, including insect management actions, on biodiversity and sustainability of forest management.

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